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Study Design

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Montréal–Mirabel–Ottawa

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STUDY DESIGN
FOR THE COMPARATIVE ASSESSMENT OF
THE TRANSRAPID SYSTEM AND AN ADVANCED RAILWAY SYSTEM
IN HIGH SPEED SERVICE BETWEEN MONTREAL, MIRABEL AND OTTAWA

By

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Canatrans Inc.

May 1982

Un sommaire en français de ce rapport est inclus avant la table des matières.

The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre, Transport Canada.

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17. Abstract

This report presents a design for a study for the comparative evaluation of two guided ground transport technologies, using a hypothetical application as an example. The technologies are the TransRapid magnetic levitation system developed in the Federal Republic of Germany and an advanced railway system to be identified in the study. The application is a high speed service between Montreal, Mirabel, and Ottawa.

The report identifies German and Canadian organizations that could be involved in the study of have an interest in it. These include the West German Federal Ministry for Research and Technology; Dornier System GmbH; Cotrem, the Montreal Region Transportation planning agency; Via Rail Canada; the Quebec Ministry of Transport.

The proposed method subdivides the study into nine phases: review of previous studies; technology documentation; performance specification; route selection; system definition; construction and operation cost estimation; impact evaluation; comparative assessment; final report.

The report also proposes a division of responsibilities between the TDC Contractor, TransRapid International, Canadian Institute of Guided Ground Transport, and the various supporting organizations. The study would last twelve months.

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17. Résumé

Ce rapport présente la conception d'une étude visant à l'évaluation, en utilisant une application hypothétique comme exemple, de deux technologies de transport terrestre: le système à lévitation magnétique Trans Rapid développé en République fédérale d'Allemagne et un système ferroviaire moderne à identifier en cours d'étude. L'application envisagée est un service à haute vitesse entre Montréal, Mirabel et Ottawa.

Le rapport identifie des organismes canadiens et ouest-allemands pouvant être impliqués dans l'étude ou y ayant un intérêt: le Ministère ouest-allemand de la recherche et de la technologie; Dornier System GmbH; le Conseil des transports de la région de Montréal; le ministère des Transports du Québec et VIA Rail Canada.

Le rapport propose une méthode d'analyse découpant l'étude en neuf phases: revue des études antérieures; documentation de chaque technologie, spécification de la performance; choix d'itinéraires; définition des systèmes; estimation des coûts de construction et d'exploitation; évaluation des impacts; évaluation comparative; rapport final.

Le rapport propose aussi une répartition de responsabilités entre le mandataire du CDT, Trans Rapid International, le Canadian Institute of Guided Ground Transport et les divers organismes extérieurs. L'étude durerait douze mois.

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SUMMARY

The background for this work is a Cooperative Agreement on Science and Technology that has existed for several years between Canada and the Federal Republic of Germany (FRG). For matters concerning transportation research and development, the parties to this agreement are represented by the Transportation Development Centre (TDC) of Transport Canada, and the Bundesministerium für Forschung und Technologie (BMFT: Federal Ministry for Research and Technology) of the FRG.

The BMFT has been funding the development of a new inter-city transportation mode using a support system based on magnetic attraction principles and techniques, the TransRapid system. This development has been undertaken for BMFT by TransRapid International (formerly, TransRapid-E.M.S.).

TDC decided to initiate a study for the comparative assessment of the TransRapid system and an advanced railway system based on conventional principles, using as a hypothetical application a high speed service between Montreal, Mirabel and Ottawa. Canatrans was retained to prepare a design, work plan, and schedule, for such a study. This is the object of this report.

Such a study would perform a comparative assessment of the TransRapid magnetic levitation system and a high speed rail system, using a service between Montreal and Ottawa via Mirabel as an example; and provide, in so doing, technical, cost and impact data on both systems for future use by inter-city transportation planners and decision-makers.

The major characteristics of the application envisioned are as follows. Mirabel is 50 km from the Montreal central business district (CBD) and 125 km from the Ottawa CBD. A high speed service between Montreal and Ottawa implies crossing the Ottawa River and its tributaries. There are at present 5 million one-way trips per year between Ottawa and Montreal: 74% by automobile, 19% by bus, 4% by rail, and 3% by air. By passing through Mirabel, the service could attract air travelers from Montreal, Quebec, and Ottawa, as it is the only airport serving those cities for scheduled international flights (to/from U.S.A. excepted).

Canatrans also identified organizations which could be involved in such a study or have a vested interest in its subject and/or results. Technical discussions were held with

these organizations and means for cooperating during the study were explored. The first such organization is the BMFT, which has funded the magnetic levitation development. The second is Dornier System which assists the BMFT in the management of this program. The Montreal region transportation planning agency, COTREM, is interested in the Montreal - Mirabel service and the provincial departments of transportation in the inter-city service. VIA Rail, as Canada's national railway passenger transport agency, is considering a magnetic levitation system as a possible alternative for Quebec - Windsor service through Montreal and Ottawa.

Successive phases of the work to be done in the study were defined as follows:

- review of previous studies for contextual and inter-city travel demand data;
- organization of basic technical documentation on each technology, irrespective of any application;
- definition of the specific functional requirements of the Montreal - Mirabel - Ottawa high speed service;
- route selection and terminal location for each technology;
- system definition for each technology;
- evaluation of constructions and operating costs and financial analysis of both systems;
- evaluation of physical, social, and economic impacts;
- summary comparative assessment outlining the major technical, cost, and impact differences between the two systems; final report.

This study should be conducted according to a work plan whereby the TDC contractor would have overall responsibility for the study and technical responsibility for contextual data, functional requirements, route selection, and impact evaluation, as well as definition and estimation of the railway system. As its subcontractor, TransRapid International would have overall responsibility for all aspects concerning the magnetic levitation technology. The final comparative assessment would be done jointly by the contractor and TransRapid International, to ensure that there is understanding and agreement regarding the results. Another subcontractor, the Canadian Institute of Guided Ground Transport (CIGGT) would be responsible for the financial analysis, using a model it previously developed for TDC. The study is estimated to require twelve months for completion.

SOMMAIRE

Le cadre de ce travail est une entente de coopération en matière de sciences et de technologie entre le Canada et la République fédérale d'Allemagne. Pour la recherche et le développement des transports, les parties sont représentées par le Centre de développement des transports (CDT) du ministère des Transports du Canada, et le Bundesministerium für Forschung und Technologie (BMFT: Ministère fédéral de la Recherche et de la Technologie). Le BMFT a financé le développement d'un nouveau mode de transport interurbain, utilisant pour sa sustentation des principes et techniques d'attraction magnétique, le TransRapid. Ce développement a été réalisé par TransRapid International (précédemment, TransRapid-E.M.S.).

Le CDT a décidé d'entreprendre une étude d'évaluation comparative du TransRapid et d'un système moderne conçu selon les principes ferroviaires classiques, en fonction des exigences d'un service à haute vitesse entre Montréal, Mirabel et Ottawa, à titre d'exemple hypothétique d'application. Canatrans fut retenue pour concevoir une telle étude et en préparer le plan de travail; ces travaux font l'objet du rapport.

Une telle étude permettrait d'évaluer les avantages et inconvénients respectifs du TransRapid et d'un système ferroviaire, au moyen d'un exemple servant à concrétiser la comparaison. On rassemblerait ainsi des données sur la technique, le coût et les impacts de ces systèmes, pour utilisation ultérieure par les planificateurs et décideurs dans le domaine du transport interurbain au Canada.

Les principales caractéristiques de l'application ensisagée sont les suivantes. La distance aérienne de Mirabel au centre-ville de Montréal est de 50 km et à celui d'Ottawa, de 125 km. Un service Montréal - Ottawa implique la traversée de la rivière des Outaouais et de deux de ses effluents. On évalue le nombre annuel de déplacements entre Montréal et Ottawa à cinq millions, répartis ainsi: 74% en voiture, 19% en autocar, 4% en train et 3% en avion. En desservant Mirabel, le service attirerait les voyageurs aériens d'Ottawa, de Montréal et de Québec, car c'est le seul aéroport qui dessert ces villes pour les vols commerciaux internationaux (sauf aux U.S.A.).

Au cours de ce travail, Canatrans a rencontré des organismes pouvant être impliqués dans une telle étude ou ayant un intérêt particulier pour ses résultats; on a analysé avec eux diverses modalités de coopération. Parmi ces organismes, on

compte d'abord le BMFT, et Dornier System, qui l'assiste dans la gestion de ce programme. Le conseil des transports de la région de Montréal s'intéresse à la liaison Montréal-Mirabel et les ministères provinciaux des transports, à la liaison interurbaine. La société nationale de transport ferroviaire de voyageurs, VIA Rail Canada, considère la lévitation magnétique comme une solution parmi d'autres dans sa planification du corridor Québec-Windsor via Montréal et Ottawa.

Les phases successives du travail à réaliser au cours de l'étude furent définies comme suit:

- revue des études antérieures pour y puiser les données sur le contexte et la demande de transport interurbain;

- compilation d'une documentation technique sur chaque système, indépendamment de toute application;

- définition des exigences fonctionnelles du service à haute vitesse Montréal - Mirabel - Ottawa;

- choix de tracés et localisation des terminus;

- définition du système pour chaque technologie;

- évaluation des coûts de construction et d'exploitation; analyse financière de chaque technologie;

- évaluation des impacts physiques, sociaux et économiques;

- évaluation comparative synthétique faisant ressortir les principales différences de technique, de coût et d'impact entre les deux systèmes; rapport final.

Selon le plan de travail proposé, le mandataire du CDT aurait la responsabilité générale de l'étude et la responsabilité technique quant aux données contextuelles, au choix d'itinéraire, à l'évaluation des impacts et à la définition et l'évaluation des coûts du système ferroviaire. La société TransRapid International, en sous-traitance, aurait la responsabilité générale de tous les aspects du système à lévitation magnétique. Le mandataire et TransRapid réaliseraient conjointement l'évaluation comparative, dans le but de s'assurer qu'il y a accord sur les résultats. Le Canadian Institute of Guided Ground Transport, serait responsable de l'analyse financière, faite à l'aide d'un modèle analytique qu'il a précédemment développé pour le CDT. La durée de l'étude est estimée à douze mois.

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INTRODUCTION

This report describes the work accomplished under a contract from the Transportation Development Centre (TDC) of Transport Canada for the design of a study for the comparative assessment of TransRapid and a railway system.

Soon after this contract was awarded, a work plan and schedule for it were prepared. This was discussed with the TDC project officer and approved by him.

Accordingly, a preliminary work plan for the study was then prepared. This consisted of a preliminary identification of tasks and of their logical interrelationships, shown as a PERT-type diagram, and a proposed subdivision of the work and responsibility, shown on a RAC Matrix.

These documents were sent to TransRapid in preparation for a discussion held in Munich in December 1981, with the TDC project officer. This discussion helped clarify and improve the PERT diagram and RAC Matrix. Also, a preliminary description of the tasks to be accomplished by TransRapid was prepared and agreed upon.

Subsequently, TransRapid presented a proposal to Canatrans, which served as a basis for estimating the cost of the portion of the study to be done by TransRapid.

After this joint work session, Canatrans undertook a series of meetings with Canadian organizations interested in this study: COTREM, the Quebec Ministry of Transport, and VIA Rail Canada. From the discussions with the various organizations, it appears that this study would generate substantial interest and cooperation.

The discussion with VIA was particularly fruitful, since this study could provide a complement to VIA's work or planning for the Quebec-Windsor Corridor: an alternative in VIA's Corridor planning consists of a Maglev system.

These dicussions, like those with TransRapid, facilitated the more precise definition of study tasks, which was being done simultaneously.

This in turn led to the clarification of the study objectives, the refinement of the method, and to a more accurate estimate of the time required for the study.

The first chapter of this report on the study design provides some historical background and identifies and explains the objectives of the study, while the second chapter gives a summary description of the characteristics of the Montreal - Mirabel - Ottawa application.

The third chapter identifies German and Canadian organizations that were consulted during this work and outlines the particular interest of each one.

The fourth chapter describes the approach and method developed for the study under this contract, while the fifth chapter presents the proposed work plan according to which they would be implemented, as well as the proposed schedule.

Conclusions of this work and recommendations resulting from it are presented in the sixth chapter.

1. BACKGROUND AND OBJECTIVES OF THE STUDY

Due to the increasing pace of urbanization and various economic factors, population concentrations have developed along corridors in many countries. The Quebec - Windsor Corridor in Canada, as the Northeast Corridor in the U.S.A., is typical in that regard: nearly 50% of the Canadian population lives along a narrow band of 900 km, where most intercity trips occur.

Beginning in the nineteen sixties and continuing into the seventies, substantial public funds were allocated for the development of innovative technology for high speed ground transportation (HSGT) systems to serve these corridors. Vehicles, components, and systems were designed, engineered, built, and demonstrated on test facilities in North America, Europe, and Japan.

Development and testing focused on new support and propulsion techniques such as a linear motors, magnetic levitation, air cushions, vacuum or gravity propulsion, etc. This is because achieving and maintaining high speeds were important objectives of these programs. These systems were designed to compete with air travel.

Significant technological innovation was required to support the development of these high speed systems. Technology had to take quantum jumps. This was not easy and, predictably, setbacks occurred: new technology was not delivering, when required, the improvements expected. There resulted a general disillusionment with new technology, not only for new systems, but also for use in conventional systems. Transportation planners and decision-makers resorted to "proven but modern" guided ground transportation (GGT) technology, which became more acceptable in the public view.

During the energy price escalation period, the situation changed drastically and the paramount criterion for transportation systems became energy efficiency rather than high speed. Trains became more attractive to the public. As a result, and also due to inflation, funding for the development of new GGT technology was severely curtailed. It was felt that, under these new conditions, new systems would not have the commercial success previously expected to offset their development costs, as well as their costs in excess of those of conventional systems, if any.

It must be realized, however, that guided ground transport systems for the Canadian corridor may be planned in the mid-nineteen eighties, built near the end of this century, and operated for fifty years or more thereafter. The unconditional use, for such an application, of conventional technology, developed in the sixties or before, must be reevaluated.

For this horizon, there are two basic alternatives: an advanced high speed rail system based on conventional principles and a contact-less system such as the TransRapid now being developed in the Federal Republic of Germany (FRG).

In such a context, a comparative assessment of conventional and innovative HSGT technology appears interesting, useful, and clearly justified. It is indeed much more realistic to consider advanced technology as a valid alternative, with its advantages and drawbacks like any other, rather than to ignore it. This is the object of the present study. Its context is explained in the following paragraphs.

For several years, the Bundesministerium für Forschung und Technologie (BMFT: Federal Ministry for Research and Technology) of the FRG has been funding the development of a new transportation mode using a support system based on magnetic attraction principles and techniques.

During this time, there has been a Cooperative Agreement on Science and Technology between Canada and the FRG. For matters concerning transportation research and development, exchanges under this agreement occur between BMFT and Transport Canada's TDC.

In July 1981, at the sixth Science and Technology Conference held in Germany under the above-mentioned agreement, the Canadian delegation reported its intention of undertaking a comparative technology assessment for a service between Montreal and Mirabel. It was suggested to include Ottawa in that analysis. Canatrans was subsequently awarded a contract for the design of such a study.

This study would contribute to achieving the following overall TDC objective: to ensure that full advantage is taken of advanced, non-contact, vehicle suspension and propulsion technology to maintain a modern, efficient and socially acceptable Canadian transportation system.

The primary objective of that study should be to perform a comparative technology assessment on a site-specific link, in order to evaluate the benefits of the TransRapid magnetic levitation system now being developed and tested in the

FRG compared to the benefits obtainable from a high speed rail system using conventional technology. Based on the specific requirements of a given application, this comparactive assessment should identify, evaluate, and analyze the essential differences between the two systems as to service, costs (construction and operation), and impacts.

A secondary objective of the study should be to provide comprehensive and comparable technical, cost, and impact data on both systems, for future use by transportation planners and decision-makers, at VIA Rail and Transport Canada in particular. No attempt should be made to formulate an overall judgment as to which system is "better" or "preferable" overall.

These objectives require that the comparative assessment focus on the essential differences between magnetic levitation and railway technology, and be as realistic as possible.

For the comparison to have the correct focus and proper emphasis, all non-essential elements shall be given the minimum reasonable attention. The objective of the study is indeed not to generate an exact and exhaustive estimate of the total cost of each technology. That implies that some system elements will be left out of the comparison altogether, unless specific differences are identified: station construction and operation costs and general management costs may be good examples of such costs.

For the study to remain manageable in scope, an already well-documented application was chosen: high speed service between Montreal and Ottawa via Mirabel. The essential characteristics of that application are described in the next chapter.

2. MONTREAL - MIRABEL - OTTAWA: A CASE FOR THE STUDY

To be realistic, the comparative technology assessment must reflect the specific geographic characteristics and service requirements of the application envisioned, a high speed service between Ottawa and Montreal, with possibly one intermediate station, at Mirabel International Airport.

The airline distance from the Montreal central business district (CBD) to Mirabel is 50 km and, from Mirabel to the Ottawa CBD, 125 km, approximately.

This application presents challenging civil engineering problems. Between Ottawa and Mirabel, the line would cross the Ottawa River. Between Mirabel and Montreal, the line would cross two smaller rivers through which the Ottawa River flows into the St. Lawrence River across the Montreal archipelago. Access to the Montreal CBD would require the construction of tunnels and/or elevated guideways, as well as, probably, the use of expressway and/or railway rights-of-way. Access to the Ottawa CBD entails similar difficulties.

The transportation requirements of a Montreal - Mirabel - Ottawa HSGT service can be envisioned from the following data. The travel demand between Montreal and Ottawa is presently around 5 million one-way trips per year, with approximately the following modal split: 74% by automobile, 19% by bus, 4% by rail, and 3% by air, according to the latest published statistics.

The annual number of movements relating to originating and terminating air passengers at Mirabel is around 1,5 million, almost exclusively international passengers (excluding those to/from the U.S.A). Of these, approximatively 15% come from the Montreal CBD and could use a HSGT for their access to Mirabel. In addition, approximatively 70 000 air passengers per year connect between Mirabel and Dorval airports, for which the interest of using a HSGT stopping at Dorval would be great. Finally, up to 90 000 air passengers connect flights at Mirabel to/from another Canadian city (quite frequently Ottawa) and could use a HSGT to reach Mirabel if the service was comparable.

There is a very substantial amount of published data and forecasts on travel between Ottawa, Montreal, and other cities in the Canadian corridor from the city of Windsor (Ontario) to that of Quebec (Québec), which could be used in this study. There is in addition a significant amount of

technical and contextual data in another project sponsored by TDC: the "Alternatives to Air" study completed in 1980 by the Canadian Institute of Guided Ground Transport (CIGGT). Maximum use should be made of that data in this study, whenever possible, to avoid duplication and focus on key issues.

3. PARTICIPATING ORGANIZATIONS

Three types of organizations will participate in this project. First, there is a promoting organization that funds the project and will provide guidance through its execution: Transportation Development Centre (TDC) of Transport Canada. Second, there are organizations that will effectively perform the study and report on it. Third, there are other organizations which have an indirect interest in this study and perhaps a more direct interest in its results. As they may be consulted during the course of the study, they are classified here as supporting organizations. More details follow on the last two groups of organizations.

3.1 Performing Organizations

Three organizations will be involved in performing this study: TDC's prime contractor, TransRapid International (formerly TransRapid-E.M.S.), and the Canadian Institute of Guided Ground Transport. Their functions in the study are described in a general way below; their specific responsibilities are identified in the RAC Matrix in Chapter 5.

3.1.1 The TDC Contractor

The TDC contractor will head the project and be responsible to TDC for the successful conduct of the study, control the project progress, and provide the project manager.

The contractor will have technical responsibility for the project methodology, for the evaluation techniques, and for information on and treatment of the railway technology. The responsibility for the evaluation will be shared with TransRapid. Furthermore, some key tasks will be done jointly by the contractor and TransRapid so as to ensure a consensus on their results.

3.1.2 TransRapid

TransRapid International will be the prime subcontractor and will perform key project tasks with the TDC contractor as outlined above. Furthermore, TransRapid will have technical responsibility for information on and treatment of the magnetic levitation technology.

3.1.3 CIGGT

The Canadian Institute of Guided Ground Transport, as a subcontractor, will be responsible for providing the

expertise for the financial analysis methodology, for which the use of their MRAIL model is planned. Furthermore, CIGGT will provide technical assistance as required on other parts of the project.

3.2 Supporting Organizations

Various organizations are concerned about railway and magnetic levitation systems and/or the Montreal - Mirabel - Ottawa problem or a part of it and, as such, will or may be consulted during the study and may have an interest in its results. Some of these organizations may become part of an Advisory Committee set up by TDC to provide advice and guidance for the study. Among such organizations, the following were consulted in the design of the study. German organizations are identified first below, followed by Canadian organizations, in alphabetical order.

3.2.1 Bundesministerium für Forschung und Technologie

The Bundesministerium für Forschung und Technologie (BMFT) (Ministry for Research and Technology of the Federal Republic of Germany) has been and is providing funding for the development of magnetic levitation technology by German industry.

The BMFT has been informed of the study by TDC and has agreed that the results of research work it has funded be made available gratis for the conduct of this study.

3.2.2 Dornier System

Dornier System GmbH assists BMFT in the management of the maglev development program: a representative of Dornier System will probably follow the progress of this study.

3.2.3 COTREM

COTREM (Conseil des transports de la région de Montréal) is an agency of the ministère des Transports du Québec that is based in Montreal and has responsibility for planning the facilities for regional transportation (private and public), in and around Montreal. As such it is responsible for planning solutions to problems related to access to the Mirabel Airport from downtown Montreal.

COTREM has been informed of the study. This organization is primarily interested in the Montreal - Mirabel part of the study. For the time being, COTREM is not actively engaged in studies on this problem, as it is waiting until a firm deadline is set for the transfer of transborder (i.e. U.S.A.) and domestic flights to Mirabel. COTREM points out, however,

that the forthcoming origin-destination survey, conducted by the Commission de transport de la Communauté urbaine de Montréal (C.T.C.U.M.) in the Fall of 1982, will provide reliable data on urban and regional travel in the Montreal - Mirabel corridor.

3.2.4 Ministère des Transports du Québec

Being responsible for the transportation of passengers in the province, the ministère des Transports du Québec has a direct interest in this study.

Its prime concern relates to ensuring that the planning and design of the intercity GGT network in Quebec is well-suited to the requirements of its residents.

3.2.5 VIA Rail Canada

As Canada's national railway passenger corporation, VIA is responsible for planning and operating railway passenger services in Canada.

VIA is now concentrating its planning efforts on the Canadian Corridor, and is studying a number of alternatives of systems and levels of service for high speed service between Quebec and Windsor via Montreal, Ottawa, Kingston, and Toronto. These alternatives rank from improved service on existing tracks to a magnetic levitation system.

VIA has been informed of this study and has expressed its interest in it. This study will be a complement to and perhaps could be in part a substitute for the analysis of the maglev alternative by VIA. This possibility was discussed informally with the VIA representative.

4. METHODOLOGY

The method proposed for this study is based on the following principles:

- to make maximum use of available data and techniques;
- to obtain new or complementary data directly from original sources;
- to ensure the cooperation of organizations that could supply useful data and/or use the results of the study;
- to obtain a realistic and significant comparison, in accordance with the objectives of the study.
- to ensure technology transfer between the FRG and Canada, the BMFT and TDC, TransRapid the TDC contractor.

This chapter is divided into three section. The first, "Scope of Work", describes in a global way the work to be done the study. The second section, "Work Breakdown", explains the eight phases into which the study is subdivided into phases while the third section, "Project Tasks", explains how the phases are themselves subdivided into tasks. These are described further individually in the appendix.

4.1 Scope of Work

The objective of this section is to provide a summary description of the work to be done to fulfill the objectives of the project, that is, to perform a comparative technology assessment and to provide, as a result, reference data on performance, configuration, cost, and impacts of magnetic levitation (maglev) and railway technology.

Early in the project, there should be a critical review of previous studies; the data that they contain, as well as their findings, should be used whenever possible, so as to avoid duplication and concentrate efforts on the specific tasks of this comparative assessment.

Simultaneously, contacts should be established (and maintained throughout the project) with organizations that can provide background data, have a vested interest in this analysis, and/or could use the results of this study. Foremost amongst such organizations is VIA Rail Canada.

Also in the initial stages of the study, existing technical and performance data on both technologies should be collated, verified and documented. This includes, but is not restricted to: speed, acceleration, curvability, gradability.

Following this initial work, a service strategy (hours of operation, service frequency, etc) and performance requirements (capacity, average speed, comfort, etc) should be specified. The service strategy and performance requirements should be the common criteria for the definition of both systems. A route between Ottawa and Montreal via Mirabel should also be selected and defined as to profile and alignment.

The comparative assessment can then effectively begin. Its first step will consist of defining the configuration of each system: vehicle type and number; power distribution and command and control equipment, etc. The second step will consist of estimating the construction costs of each system as configured, based on the same estimation method for both.

Next, operating costs will be estimated for the base year. Quantity and unit cost data should be provided for on-board, central, and maintenance personnel up to first-line management; traction energy, system energy, etc. Construction and operating costs thus estimated should be the basis for a financial analysis of the two sysems, using the same method for both.

Impacts of both systems should then be identified and evaluated on the same basis. This includes, but is not restricted to: environmental, social, economic, and industrial impacts, energy and ridership impacts, technical risks and spin-offs, and any other relevant impacts. Rather than attempt to consider all possible impacts, this analysis should focus on the major impacts and their essential differences between the two technologies.

Finally, the study should terminate on a summary comparison of the technical, financial and impact aspects of the two technologies, outlining the major differences. These will be documented, along with the other findings of the study, in a final report.

4.2 Work Breakdown

The objective of this section is to outline the proposed subdivision of the project into seven distinct phases and describe the work to be done in each phase. A phase will be made up of a number of interrelated activities and its termination will be a project milestone. In most cases, a milestone report will also conclude the phase. The breakdown of each phase into activities or tasks is discussed in the next section.

4.2.1 Phase 1: Review of Previous Studies

Work in this phase will consist of identifying previous studies of interest to the project, reviewing the most relevant ones, and synthesizing their most significant data, results, and findings.

The studies of concern here are those that define and evaluate systems designed to provide service between Montreal and Ottawa, between Montreal and Mirabel, and in the Quebec-Windsor Corridor through Montreal, Mirabel, and/or Ottawa. The analysis of these studies and the synthesis of their major findings should provide the necessary background data for defining the basic contextual parameters of the Montreal - Mirabel - Ottawa service: geography, topography, land use, population densities, travel demand and forecasts, etc.

As part of the review of previous studies, consultations will be held with the various Canadian concerned organizations, some of which may be represented on the Advisory Committee.

The objective of these consultations is to ensure that all recent studies are being given all due consideration and that relevant concerns of these organizations are adequately taken into account in the study. This will enhance the usefulness of the results of this study to these organizations.

4.2.2 Phase 2: Technology Documentation

The objective of this phase is to constitute a compendium of existing technical and performance data on each of the two technologies. Work will consist of reviewing technical reports on maglev and high-speed rail. This search will also probably yield cost and impact data on both technologies, which could be a useful reference for later phases of the study, but will not be directly applicable to the comparative assessment.

Information on the TransRapid will be supplied by its developer. For the railway technology, it will be first necessary to identify a specific system which constitutes a valid alternative. An electrified LRC train is the alternative envisioned, because the necessary documentation could be obtained readily and free of charge from manufacturers and other Canadian sources.

The result of Phase 2 will be summarized in a short list of key technical parameters such as speed, longitudinal acceleration, deceleration, jerk, curvability, gradability, etc.

4.2.3 Phase 3: Performance Specification

The objective of this phase is to define the minimum service and performance requirements that will have to be met by each of the two technologies. One technology could exceed those minimum requirements.

To do this, the target market will be identified. This implies a determination of its significant characteristics, which will result from an estimation of the capturable ridership and a description of the expectations of potential riders. It should be stressed that no new demand analysis will be undertaken to identify the target market and define its characteristics: this will be done by a comparative evaluation of the results of previous studies.

Next, a service strategy will be defined, covering operating schedules, desirable comfort and convenience, intermediate stations, etc. This strategy will be designed in response to key expectations of potential riders that constitute the target market, as revealed by previous studies.

To translate this service strategy into a level of service offered to potential users, the system must offer a given performance, which will now be specified: capacity, frequency, average speed, acceleration, jerk and vibration in the three axes, static and dynamic comfort, noise levels, etc. When all major parameters of performance are specified, then preliminary system design can start.

4.2.4 Phase 4: Route Selection

Since the comparative evaluation is made for a given application, it is necessary to select an alignment and profile for the system, because these will define the necessary infrastructure and structures, which will be major cost components.

This phase will begin by gathering the necessary background maps. For urban areas, maps will be at the 1:50 000 scale; for rural areas, 1:100 000. Topographical and other features not appearing on such maps will not be considered in the analysis, unless they were explicitly identified in a previous study.

As soon as the service strategy is defined, it becomes possible to select an alignment for access to Ottawa and Montreal, which will provide access to the terminal since its functional location is part of the service strategy. The selection of an alignment in high-density urban areas will be

primarily dictated by the availability of usable rights-of-way, so it can be done before system performance is specified.

Once the required performance is known, the urban access links can be connected with rural line-haul links of a geometry that corresponds to the specified speed and comfort levels.

In addition, the maglev route and the railway route will be separately optimized and adapted to take maximum advantage of the individual capabilities of each mode.

4.2.5 Phase 5: System Definition

The specific objective of this phase is to provide the necessary technical data for a detailed estimation of the construction and operation costs of each technology, based on the alignment and profile selected for it in the preceding phase.

Each system will be schematically designed and preliminarily dimensioned to meet the performance requirements while providing the service specified; the resulting system configuration and operational plan will be the basis for cost estimation.

The system configuration as defined will materialize as a comprehensive list of all physical elements and components that are required for the system to be fully operational according to specifications, together with a brief description of said components and the estimation of the quantity required of each. This will include such items as length of infrastructure, guideway (at grade, elevated), track, structures, vehicles, wayside and central power distribution and signalling equipment, etc. It should be stressed that defining the system configuration will not imply any preliminary or detailed engineering work.

The operational plan will provide enough data for a detailed estimation of the number of on-board and central operators; it will describe in detail the normal system requirements for operation and maintenance.

4.2.6 Phase 6: Cost Estimation

At the beginning of this phase, a cost estimation method will be selected and defined; that method will be used to estimate the costs of both systems, so as to ensure a greater degree of objectivity and estimate comparability.

Construction costs will then be estimated based on quantities evaluated in the previous phase and unit costs developed to reflect construction labor and equipment requirements, wages, and costs. Labor productivity will be based on observations of actual, recent and comparable construction projects. The approach will be similar to that currently used by construction contractors in preparing their bids, subject to constraints resulting from the level of detail attained in defining the system configuration.

This estimate will thus yield quantities, unit and total costs for the major system elements, such as guideway and/or track length (at-grade, elevated, tunnels, bridges), vehicles, track and switches, fixed signaling and power conditioning and distribution equipment, etc. System elements justifiably presumed identical for both systems will be identified and their costs may not be estimated.

Similarly, operating costs, up to and including first-line management, will be estimated based, as much as practicable, on observed wages and productivity. As productivity currently differs widely between modes, reflecting various collective agreements, the choice of a productivity level for the estimation will be based on explicitly-stated assumptions. Energy costs will reflect current power pricing.

Once construction and operating costs have been estimated for both technologies, an attempt will be made to optimize each system design to achieve the lowest reasonable cost; service requirements may be modified as a result of this optimization.

Once both systems are optimized, a financial analysis will be performed on each one. The financial analysis will evaluate the unit ticket cost such that, with the given traffic levels, costs will be fully recovered, including capital, financing, and operating costs. Modifications will be made as required to ensure that the calculated ticket cost is coherent with the expected ridership.

4.2.7 Phase 7: Impact Evaluation

The evaluation will focus on the significant impacts that differ between the two technologies. No attempt will be made to identify all possible impacts or to assign them an economic value. Impacts will be evaluated in physical units only and they will not be assigned a monetary value.

The following impacts will be considered separately for each technology: technical or operational imponderables, risks,

or potential problems; winter operation problems; technology spin-offs and manufacturing impacts; energy impacts; socio-economic and environmental impacts; traffic and ridership impacts.

4.2.8 Phase 8: Comparative Assessment

The objective of this last phase of the study is to synthesize its key findings, emphasizing the significant differences between the two technologies.

This will be done by preparing three formal comparisons of the two systems: one on their technical characteristics; one on their capital and operating costs; one on their major impacts.

The findings of these comparisons will be summarized in the final report. No attempt will be made to state or imply a preference for a technology, as the objective is to outline their differences, not to select the "better" technology.

4.2.9 Phase 9: Final Report

A final report will be prepared to present and document the major findings of the study, especially those of Phase 8. This will be submitted to TDC for comments and modified as required upon receipt of the comments.

4.3 Project Tasks

Tasks or activities required for the completion of this project have been identified and are described in Appendix A.

This description consists of the specific objective of each tasks, the methodology envisioned to perform it, a note on which organization (of those listed in 3.1) will be responsible for it, and the expected results.

Tasks are numbered according to the project phases identified in the preceding section; for instance, Task 1.1 is the first task in Phase 1. When the same task must be performed (usually separately and in parallel) for railway and maglev, the same task number and title are used; the number is followed by a suffix, M for maglev and R for railway.

5. WORK PLAN

While devising an appropriate method for the conduct of the Montreal - Mirabel - Ottawa technology assessment study, the work package described in the preceding chapter was subdivided into well-defined and manageable tasks.

Whereas the object of the previous chapter was primarily to describe what should be done, the object of the present is thus to outline how it should be done. Accordingly, information is provided on the responsibilities of the various organizations involved in the study.

This information will be presented by organization, by phase, and by task, successively.

5.1 Work Plan for Each Organization

5.1.1 The TDC Contractor

The prime contractor will have overall responsibility for the project and ensure coordination by appointing the project manager, who will be the normal contact with TDC. He will also be responsible for preparing the final report.

Technically, the TDC contractor will be responsible for Phase 1 (Previous Studies), Phase 3 (Performance Specification), Phase 4 (Route Selection), Phase 7 (Impact Evaluation), and Phase 9 (Final Report). He will also be responsible for the analysis of the rail system in Phase 2 (Technology Documentation), Phase 5 (System Definition), and Phase 6 (Cost Estimation).

The TDC contractor will be jointly responsible with TransRapid for Phase 8 (Comparative Assessment). This is to ensure that the assessment is a common evaluation and that both parties agree on it. The TransRapid project manager will work in the contractor's office during that phase.

5.1.2 TransRapid

As a subcontractor, TransRapid will be responsible for studying the magnetic levitation technology in Phase 2 (Technology Documentation), Phase 5 (System Definition) and Phase 6 (Cost Estimation). Its project staff will be based in Munich.

TransRapid will be jointly responsible with the TDC contractor for Phase 8 as outlined above. Furthermore, TransRapid will be informed on other project phases and be invited to comment, particularly on Phase 7 (Impact Evaluation).

5.1.3 CIGGT

CIGGT will be responsible for Task 6.6 (Financial Analysis). Furthermore, CIGGT will be jointly responsible with the TDC contractor and TransRapid for Task 8.3 (Financial Comparison). CIGGT project staff will usually work in Kingston. Also, CIGGT may be requested to supply expertise on some tasks as the need arises.

5.2 Work Plan by Phase

Detailed project planning will be performed by the TDC contractor. This preliminary phase includes negotiations of the contracts between the contractor and TransRapid. This negotiation will take place in Munich, to ensure that the project manager meets all the TransRapid project staff, which will normally be based there.

Phase 1 (Previous Studies) will be done by the TDC contractor, with some help from TransRapid. The synthesis of previous studies which will conclude that phase will consist of a text presenting and explaining the contextual data that will be the basis of the comparative assessment. Discussions with other organizations involved in the study will also be conducted in this phase, to define mechanisms for their participation.

Phase 2 (Technology Documentation) will be done in parallel by the TDC contractor and TransRapid, for the rail and maglev technology, respectively. This phase will be concluded by the preparation of two data sheets (short text with tables) which will be submitted to the Advisory Committee.

Phase 3 (Performance Specification) will be done primarily by the TDC contractor. TDC will be requested to approve the selection of a target market. Its requirements will be the basis for formulating system performance criteria to be met by both technologies. These criteria will be reviewed by the contractor and TransRapid in a joint milestone task (Task 3.3) which will conclude Phase 3 and result in a text describing the performance specifications adopted for system definition.

Phase 4 (Route Selection) will be done by the TDC contractor. The selection or adoption of two alignments, one for rail, one for maglev (possibly identical in total or in part) will

conclude this phase. This will be done with a limited participation of TransRapid and CIGGT. The proposed alignments will be submitted to the Advisory Committee for information, and to the TDC for technical approval.

Phase 5 (System Definition) will be done by the TDC contractor for rail and TransRapid for maglev. Frequent communications between the two will ensure technical consistency. This phase will conclude by the preparation of a detailed descriptive report on each technology. These two reports will later become chapters of the final report.

Phase 6 (Cost Estimation) will be done as Phase 5 with the following modifications. The Financial Analysis (Task 6.6) will be performed by CIGGT, which will also be asked to comment on the cost estimation method defined at the beginning of the phase. Phase 6 will conclude on a brief report on the results of the financial analysis.

Phase 7 (Impact Evaluation) will be done by the TDC contractor. TransRapid will participate actively in some tasks of this phase and comment on the result of others. This phase will conclude on the preparation of several brief reports, one on each impact analyzed. These will eventually constitute appendices to the final report.

Phase 8 (Comparative Assessment) is the synthesis of the whole study. The two technologies will be compared as to their technical and financial characteristics and their impacts. This phase will be conducted as an extended design review of the whole study; the TransRapid project manager will be based in the contractor's office for the duration of that phase and work on a daily basis with the project manager. Phase 8 will conclude in the preparation of three reports corresponding to Tasks 8.1, 8.2, and 8.3, respectively. These reports will each constitute a chapter of the final report.

Phase 9 (Final Report), done by the TDC contractor, will aggregate and organize all the elements generated throughout the study into a final report. This report will focus on the key issues only and the technical and financial back-up will be appended.

5.3 Work Plan by Task

The RAC matrix that follows attached provides an identification of the responsibility of each organization for each task.

RAC MATRIX (Responsibility, Authority, Communications)
MATRICE R.A.C. (Responsabilité, Autorisations, Communications)

MONTREAL - MIRABEL - OTTAWA COMPARATIVE TECHNOLOGY ASSESSMENT (Page 1 of 2)

	0.1 Tasking and Mobilization	1.1 Identify Previous Studies	1.2 Review Relevant Studies	1.3 Synthesize Significant Findings	1.4 Consult Concerned Organizations	2.1R Document Technology (Rail)	2.1M Document Technology (Maglev)	2.2R Key Parameters (Rail)	2.2M Key Parameters (Maglev)	3.1 Identify Target Market	3.2 Define Service Strategy	3.3 Specify System Performance	4.1 Prepare Base Maps	4.2 Select Montreal Access	4.3 Select Ottawa Access	4.4 Locate Intermediate Stations	4.5 Adopt System Alignment(s)	5.1R System Definition (Rail)	5.1M System Definition (Maglev)	5.2R Operational Plan (Rail)	5.2M Operational Plan (Maglev)	6.1 Cost Estimation Methodology	6.2R Implementation Costs (Rail)	6.2M Implementation Costs (Maglev)	... to be continued
TDC Director General	■									■															
TDC Project Officer	▽		Ⓒ							▽		▽					▽								
Advisory Committee				○	○			▽	▽	○	○						○								
Canatrans	●	●	●	●	●	●	Ⓐ	●	Ⓐ	●	●	●	●	●	●	●	●	●	Ⓐ	●	Ⓐ	●	●	▲	
Trans Rapid	○	Ⓒ		▽	▽	▽	●	▽	●	▽	Ⓒ	●					Ⓒ	○	●	○	●	Ⓒ	Ⓒ	●	
CIGGT				▽				▽	▽								Ⓒ					Ⓒ			
Dornier Systems				▽			△		▽																
BMFT							△																		
COTREN			○		▲					△				▲		▲									
Transports Québec					▲								▲			△									
VIA Rail Canada			○		▲	△				△				△		△	▽	▲	▲	▲	▲				

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DATE	by / par

LEGEND: LEGENDE:

RESPONSIBILITY RESPONSABILITE ○
- Prime Performance Totale ●
- Limited Performance Partielle ○
- Coordination Decoordination Ⓐ
- Comments Commentaires Ⓒ

AUTHORITY AUTORISATIONS □
- Must Approve; Executive Approbation administrative ■
- Must Recommend For Approval Recommandation □
- Must Approve; Professional Approbation technique ▽

COMMUNICATION COMMUNICATIONS △
- Must Be Consulted A consulter ▲ — Discussion verbales
- Must Be Informed A tenir au courant △ — Discussion verbales
- Must Advise or Guide Conseiller ou orienter ▼ — Written écrites
- Must Be Advised A tenir au courant ▽ — Written écrites

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RAC MATRIX (Responsibility, Authority, Communications)
MATRICE R.A.C. (Responsabilité, Autorisations, Communications)

MONTREAL - MIRABEL - OTTAWA COMPARATIVE TECHNOLOGY ASSESSMENT (Page 2 of 2)

Continued	6.3R Operating Costs (Rail)	6.3M Operating Costs (Maglev)	6.4 Optimize Service and System	6.5 Revise Cost Estimations	6.6 Financial Analysis	7.1 Technical Imponderables	7.2 Winter Operation Analysis	7.3 Technology Spin-offs	7.4 Manufacturing Impacts	7.5 Energy Impacts	7.6 Socio-Economic Impacts	7.7 Environmental Impacts	7.8 Traffic Impacts	8.1 Technical Comparison	8.2 Financial Comparison	8.3 Impact Comparison	8.4 Sensitivity Analysis	9.1 Draft Final Report	9.2 TDC Comments	9.3 Final Report				
TDC Director General																			○	■				
TDC Project Officer					▽													▽	●	□				
Advisory Committee																								
Canatrans	●	Ⓐ	●	●	Ⓐ	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●				
Trans Rapid	Ⓒ	●	●	●	Ⓒ	●	●	●	Ⓒ	Ⓒ	Ⓒ	Ⓒ	Ⓒ	●	●	●	●	○		○				
CIGGT					●								Ⓒ		●					○				
Dornier Systems				△	△													△						
BMFT				△	△													△						
COTREM																								
Transports Québec																								
VIA Rail Canada			▲	△	△								△				▲							

BAG	13/05/82
DATE	by / par

LEGEND: LEGENDE:

RESPONSIBILITY RESPONSABILITE ○
- Prime Performance Totale ●
- Limited Performance Partielle ○
- Coordination De coordination Ⓐ
- Comments Commentaires Ⓒ

AUTHORITY AUTORISATIONS □
- Must Approve; Executive Approbation administrative ■
- Must Recommend For Approval Recommandation □
- Must Approve; Professional Approbation technique ▽

COMMUNICATION COMMUNICATIONS △
- Must Be Consulted A consulter ▲ — Discussion verbales
- Must Be Informed A tenir au courant △ — Discussion verbales
- Must Advise or Guide Conseiller ou orienter ▼ — Written écrites
- Must Be Advised A tenir au courant ▽ — Written écrites

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6. CONCLUSIONS AND RECOMMENDATIONS

Work under this contract has led to the development of an appropriate method for performing the envisioned study for a comparative technology assessment.

This method was used as a basis for defining a set of tasks, a work plan, a schedule, and a budget for the study.

While doing this, German and Canadian organizations were consulted and expressed significant interest for cooperating in the study.

TransRapid International and CIGGT are prepared to undertake certain parts of that study as subcontractors to Canatrans, which is prepared to submit a proposal to TDC for this study.

Based on the interest generated from all parties, it is recommended to undertake this study.

Based on VIA's ongoing work for planning the Quebec-Windsor Corridor, and the timing of that work, there are advantages to undertaking that study in the near future. Its results could provide a direct input to the analyses soon to be performed by VIA Rail.

A. DESCRIPTION OF PROJECT TASKS

The objective of this appendix is to identify all the tasks into which the project is subdivided and to describe their content. This is done by presenting a list of tasks (Table A-1) and a one-page description on each.

This description first outlines the specific objective of each task; the objective identifies what is to be accomplished by performing this task. Then, a methodology is proposed for the accomplishment of the task, under this heading are also found the sources of data to be used in the tasks.

The third heading, "responsibility", identifies which of the participating and performing organizations is primarily responsible for performing this task; more information is provided on the distribution of responsibilities in the RAC matrix elsewhere in the report.

Finally, under the heading "result", there is a brief description of the expected result of the task and how they will be presented. Occasionnally, a note presents some important aspect of the task that does not fit the four other headings.

As mentioned earlier (Section 4.3), the tasks are in principle numbered according to the eight phases of the project identified in Section 4.2.

For the purpose of systematic numbering, an additional phase was created when identifying the tasks: Phase 0 concerns tasks to be performed before the start of Phase 1.

Table A-1

List of Project Tasks

Phase	Tasks
1. Synthesis of Previous Studies Planning & Coordination	1.1 Identify Previous Studies 1.2 Review Relevant Studies 1.3 Synthesize Significant Findings 1.4 Consult Concerned Organizations
2. Technology Documentation	*2.1 Document Technology *2.2 Key Parameters
3. Performance Specification	3.1 Identify Target Market 3.2 Define Service Strategy 3.3 Specify System Performance
4. Route Selection	4.1 Prepare Base Maps 4.2 Select Montreal Access Route 4.3 Select Ottawa Access Route 4.4 Locate Intermediate Stations 4.5 Adopt System Alignment(s)
5. System Definition	*5.1 System Definition *5.2 Operational Plan
6. Cost Estimation	6.1 Cost Estimation Methodology *6.2 Estimation of Implementation Costs *6.3 Estimation of Operating Costs 6.4 Optimize Service and System 6.5 Revise Cost Estimations 6.6 Financial Analysis
7. Impact Evaluation	7.1 Evaluate Technical Imponderables 7.2 Analyze Winter Operation Problems 7.3 Identify Technology Spin-Offs 7.4 Evaluate Manufacturing Impacts 7.5 Evaluate Energy Impacts 7.6 Socio-Economic Impacts 7.7 Environmental Impacts 7.8 Evaluate Traffic Impacts
8. Comparative Assessment	8.1 Summary Technical Comparison 8.2 Summary Financial Comparison 8.3 Summary Impact Comparison 8.4 Sensitivity Analysis
9.1 Final Report	9.1 Draft Final Report 9.2 Comments by TDC 9.3 Final Report

(*) Each of these tasks is subdivided into two identical tasks, one for rail (R) and one for Maglev (M).

Task 0.1

TASKING AND MOBILIZATION

Objective : To finalize the detail of the Work Plan and to make the arrangements necessary to ensure that the personnel assigned to the project be made available when required.

Methodology : This task will be done in three stages. First, as soon as the contract is awarded, Canatrans will mobilize its personnel. Phase 1 will then start. As basic data is found in studies and cooperation is obtained from supporting organizations, the preliminary Work Plan will be refined. At the end of Phase 1, the TransRapid personnel will be mobilized based on the revised Work Plan.

Responsibility : Each subcontractor for its personnel and mandate. Contractor for the project overall, its personnel and subcontractors.

Result : Final detailed Work Plan with schedule, responsibilities, and personnel assignment. Corporate agreements for personnel assignment.

Authority : The task plan must be approved by TDC.

Task 1.1

IDENTIFY PREVIOUS STUDIES

Objective : To obtain a comprehensive list of application studies performed in the last ten years on:
- Montreal - Mirabel regional service;
- Montreal - Ottawa intercity transport;
- Railway and/or Maglev applications to the Canadian Corridor.

Methodology : Computerized literature search complemented by discussions with concerned Canadian agencies.

Responsibility : TDC Contractor;
TransRapid will comment.

Result : The list of Studies, with abstracts whenever possible.

Note : There exist studies on the application of Maglev to other locations. If they present a methodological interest, they would be added to the list by TransRapid.
Technical studies will be reviewed in Tasks 2.1 and 2.2.

Task 1.2

REVIEW RELEVANT STUDIES

Objective : Based on the list of references resulting from Task 1.1, review the content of the studies that appear directly relevant or significant.

Methodology : Not applicable.

Responsibility : TDC Contractor.

Result : A knowledge of the content of these studies.

Task 1.3

SYNTHESIZE SIGNIFICANT FINDINGS

Objective : To summarize the significant findings of the relevant application studies reviewed in Task 1.2. Significant findings are those that have a direct application to this study, such as contextual data, travel demand forecasts, etc.

Methodology : Not applicable.

Responsibility : TDC Contractor.

Result : A text describing the contextual, travel demand, and other data, taken from previous application studies, that will serve as a basis for this study. In the case of conflicting data, a choice will be made and explained.

Task 1.4

CONSULT CONCERNED ORGANIZATIONS

Objective : To establish contact and a working relationship with Canadian organizations that:
- could provide background data or advice;
- have a vested interest in this analysis and/or application, and/or
- could use the results of this study.

Methodology : Since most of these organizations will have been contacted during the study design, this will be a resumption of previously-established contacts. Plans for cooperating during the study will be discussed in detail, and an agreement on cooperation will be sought.
Contacts will be maintained throughout the study, regularly or occasionnally as required.

Responsibility : Contractor. The Advisory Committee set up by TDC will be the forum for on-going contacts with such organizations.

Result : These organizations will be informed of the progress of the study and their preoccupations will be given due consideration.
An agreement on means of cooperations and/or exchange of information during the study.

Task 2.1R

DOCUMENT TECHNOLOGY (RAIL)

Objectives : 1. To select the railway technology that will be used for the comparative assessment.

2. To located, collate, and to assemble the latest technical, cost, and impact information on that technology for further use and references during the study.

Methodology : Consultation of VIA Rail is of prime importance for this task. Ideally, the high speed rail system used in this study will be same as VIA's Number Five alternative for its corridor study. Complementary information will be obtained from manufacturers.

Responsibility : TDC Contractor.

Result : A brief report describing the railway technology adopted, the reason for its choice, and a structured presentation of the base data, with a copy of source reports.

Task 2.1M

DOCUMENT TECHNOLOGY (MAGLEV)

Objective : To locate, collate, and assemble a compendium of the latest technical, cost, and impact information on the TransRapid System for further use and reference during the study.

Methodology : No new research is expected, but the gathering and organization of data contained in existing reports.

Responsibility : TransRapid.

Result : A copy of the source reports with a guide to their contents. If these reports are written in German, the table of contents will be translated and selected sections upon request by TDC when necessary for the understanding of some significant technical aspect of the maglev technology.

Task 2.2R

KEY PARAMETERS (RAIL)

Objective : To prepare a summary description of the operational capabilities of the railway technology that will be used in the comparative assessment, as it is presently developed. This description will take the form of a list of key performance parameters, with a value for each.

Methodology : A list of significant and/or representative performance parameters will first be drawn; this list will be the same for both technologies. Then, from an analysis of the documentation assembled in Task 2.1R, values will be selected for each parameter; they will be referenced to that documentation.

Responsibility : TDC Contractor.

Result : Representative characteristics of the technology. Values for descriptive parameters, including the following:
Maximum speed;
Normal cruising speed on tangent;
Maximum and average acceleration;
Maximum and average service deceleration;
Maximum emergency deceleration;
Minimum radius of horizontal and vertical (sag and crest) curvature.

Task 2.2M

KEY PARAMETERS (MAGLEV)

Objective : To prepare a summary description of the operational capabilities of the TransRapid system as it is presently developed.
This description will take the form of a list of key performance parameters and their value, for the TransRapid system that would be the comparative assessment.

Methodology : Based on the list of significant and/or representative performance parameters developed in Task 2.2R, the values will be extracted from the reports gathered in Task 2.1M, with analysis and/or modifications as required.

Responsibility : TransRapid.

Result : Representative characteristics of the technology. Values for descriptive parameters, including the following:
Maximum speed;
Normal cruising speed on tangent;
Maximum and average acceleration;
Maximum and average service deceleration;
Maximum emergency deceleration;
Minimum radius of horizontal and vertical (sag and crest) curvature.

Task 3.1

IDENTIFY TARGET MARKET

Objective : Travel demand data and forecasts and the expected modal split will have been synthesized from previous studies in Task 1.3. The objective of the present task is to extract from this information an identification of the segment of the travel market that should be the logical target of the high-speed Montreal - Mirabel - Ottawa service, together with its characteristics.

Methodology : Analysis of the various travel demand forecasts and modal split predictions, followed by a comparative evaluation of their rationale. Selection of the appropriate target. Approval requested from TDC.

Responsibility : TDC Contractor.

Result : A brief description of the target market: what types of travelers make it, what are their likes and dislikes in intercity transportation systems, what service attributes they value most highly.

Task 3.2

DEFINE SERVICE STRATEGY

Objective : To define the level of service that must be provided to make the Montreal-Mirabel-Ottawa service responsive to the requirements of that segment of the travel market identified as its target in Task 3.1.

Methodology : Not applicable

Responsibility : Contractor; TransRapid will comment.

Results : Values for all the major level-of-service parameters expected to have a significant impact on market success and/or system configuration and costs, including:

- approximate location of Montreal and Ottawa terminals (in relation to the CBD)
- approximate location of the Mirabel Station (inside or outside the air terminal)
- number and location of other intermediate stops if any
- average, minimum, and maximum frequency of departures
- terminal-to-terminal travel time
- time of earliest and latest departures
- weekday vs weekend service
- expected daily ridership

Task 3.3

SPECIFY SYSTEM PERFORMANCE

Objective : To define the functional requirements to be met by both technologies, in terms of minimum system performance. The preceding task was concerned by system attributes as perceived by the user, this one is aimed toward system definition.

Methodology : To translate the level-of-service parameters identified in Task 3.2 into the corresponding system performance parameters.

Responsibility : Contractor and TransRapid
This task will be done jointly and constitutes a project milestone, documented by a progress report.

Results : Values for the major system performance parameters, including:

- average speed
- minimum interval
- number of departures per day
- line and train capacity
- ac/deceleration and jerk along the three axes
- vibration standards

Task 4.1

PREPARE BASE MAPS

Objectives : 1. To assemble all the published maps necessary for the selection of alignments.

2. To prepare the base maps on which the alternative alignments will be analyzed and the selected alignments displayed.

Methodology : Contacts with Governmental agencies to ensure that the most up-to-date versions are available and their relevant projects are taken into account.

Responsibility : TDC Contractor.

Result : A series of base maps covering, by sections, all the territory of interests between the Montreal and Ottawa terminals and around them.

Task 4.2

SELECT MONTREAL ACCESS ROUTE

Objective : To select the alignment to be used by the system to have access to the terminal.
Each technology may have its own alignment.

Methodology : Overlay on base maps prepared in Task 4.1, followed by site visits to effect a preliminary feasibility check. Alignments following existing rights-of-way will be preferred.

Note : The functional or approximate location of this terminal was selected in Task 3.2. A more precise location will be selected as part of the present task.

Responsibility : TDC Contractor.

Result : Route overlays on 1:50000 base maps, showing the alignments selected for each technology throughout the urban area.

Task 4.3

SELECT OTTAWA ACCESS ROUTE

Objective : To select the alignment to be used by the system to have access to the terminal.
Each technology may have its own alignment.

Methodology : Overlay on base maps prepared in Task 4.1, followed by site visits to effect a preliminary feasibility check. Alignments following existing rights-of-way will be preferred.

Note : The functional or approximate location of this terminal was selected in Task 3.2. A more precise location will be selected as part of the present task.

Responsibility : TDC Contractor.

Result : Route overlays on 1:50000 base maps, showing the alignments selected for each technology throughout the urban area.

Task 4.4

LOCATE INTERMEDIATE STATIONS

Objectives : 1. To select a reasonably precise location for the Mirabel station and for others if any.

2. To select alignments for access to these stations from Montreal and from Ottawa in each case.

Methodology : As Task 4.2

Responsibility : TDC Contractor.

Result : As Task 4.2, areas around stations.

Task 4.5

ADOPT SYSTEM ALIGNMENT(S)

Objective : To complete the work already done in Phase 4 by connecting the route segments already located around terminals and intermediate stations. This will be done separately for each technology.

Methodology : Work on base maps followed by local visits for a preliminary feasibility check. Existing information used to maximum possible extent.

Responsibility : TDC Contractor.
Comments by TransRapid, CIGGT, and the Advisory Committee

Result : For each technology, the route will be completely sketched out and shown overlaid on the base maps, at 1:50000 scale for urban areas and 1:100000 scale for rural areas.

Task 5.1 R

SYSTEM DEFINITION (RAIL)

Objective : To identify, describe, and enumerate all the physical elements that are necessary for the system to be operational.

Methodology : A preliminary design of each technology will be effected, the design being such that the system meets the specified performance requirements along the selected alignment.

This will be done using a heuristic approach based on the consultants' experience in GGT system design. The method used for defining and configuring, the system will be fully documented a posteriori, as well as specification compliance.

The system will be dimensioned to the level of detail necessary for a reliable cost estimation. No preliminary or detailed engineering will be performed.

Responsibility : TDC Contractor.
Interaction with TransRapid

Results : Identification, description, dimensioning, and/or enumeration of all system elements, including the following:

- land acquisition if any
- guideway length:at grade, in cuts or on fill, underground
- structures:bridges,overpasses, underpasses, length of elevated guideway
- track and switches (on-line and storage area)
- vehicles
- electrical substations and conductors
- signalling equipment (central and wayside) and conductors
- all other system elements necessary for operation and maintenance.

Task 5.1 M

SYSTEM DEFINITION (MAGLEV)

Objective : To identify, describe, and enumerate all the physical elements that are necessary for the system to be operational.

Methodology : A preliminary design of each technology will be effected, the design being such that the system meets the specified performance requirements along the selected alignment.

This will be done using a heuristic approach based on the consultants' experience in GGT system design. The method used for defining and configuring, the system will be fully documented a posteriori, as well as specification compliance.

The system will be dimensioned to the level of detail necessary for a reliable cost estimation. No preliminary or detailed engineering will be performed.

Responsibility : TransRapid
Coordination by Contractor.

Results : Identification, description, dimensioning, and/or enumeration of all system elements, including the following:

- land acquisition if any
- guideway length:at grade, in cuts or on fill, underground
- structures:bridges,overpasses, underpasses, length of elevated guideway
- track and switches (on line and storage)
- vehicles
- electrical substations and conductors
- signalling equipment (central and wayside) and conductors
- all other system elements necessary for operation and maintenance.

Task 5.2 R

OPERATIONAL PLAN (RAIL)

Objective : To identify and describe the procedures to be used for operating the system, as well as the major types of operating jobs.

Methodology : The operational plan must be sufficiently detailed for estimating personnel requirements.

Responsibility : TDC Contractor.
Interaction with TransRapid.

Result : An operational plan identifying the types of positions to be,filled sufficiently detailed to allow a rapid estimation of the personnel required.

Task 5.2 M

OPERATIONAL PLAN (MAGLEV)

Objective : To identify and describe the procedures to be used for operating the system, as well as the major types of operating jobs.

Methodology : The operational plan must be sufficiently detailed for estimating personnel requirements.

Responsibility : TransRapid
Coordination by Contractor.

Result : An operational plan identifying the types of positions to be filled,sufficiently detailed to allow a rapid estimation of the personnel required.

Task 6.1

COST ESTIMATION METHODOLOGY

Objective : To define a method to be used for estimating construction and operating costs. This method will be used for both technologies to ensure consistency and comparability of the two estimates.

Methodology : The method will be based on a method previously used with success for a similar evaluation.

Responsibility : Contractor, with comments by TransRapid and CIGGT.

Result : A text describing the method. This text should outline clearly the procedures to be used in the estimation.

Task 6.2 R

ESTIMATION OF IMPLEMENTATION COSTS (RAIL)

Objective : To obtain a comprehensive estimation of the sums required for designing, engineering, productionizing, procuring, testing and commissioning all the system elements identified in Task 5.1 R.

Methodology : Costs will be estimated according to the method defined in Task 6.1. First, unit costs will be defined for Canadian conditions and verified. Second, these unit costs will be multiplied by the quantities estimated in Task 5.2 R.

Responsibility : TDC Contractor
Comments by TransRapid

Result : A complete list of unit and total costs for all system elements, as per Task 5.2 R.

Note: : System elements that can logically be hypothesized equal for both systems will not be estimated. This may include station construction, for instance.

Task 6.2 M

ESTIMATION OF IMPLEMENTATION COSTS (MAGLEV)

Objective : To obtain a comprehensive estimation of the sums required for designing, engineering, production-izing, procuring, testing and commissioning all the system elements identified in Task 5.1 M.

Methodology : Costs will be estimated according to the method defined in Task 6.1. First, unit costs will be defined for Canadian conditions and verified. Second, these unit costs will be multiplied by the quantities estimated in Task 5.2 M.

Responsibility : TransRapid
Coordination by Contractor.

Result : A complete list of unit and total costs for all system elements, as per Task 5.2 M.

Note: : System elements that can logically be hypothesized equal for both systems will not be estimated. This may include station construction, for instance.

Task 6.3 R

ESTIMATION OF OPERATING COSTS (RAIL)

Objective : To obtain a comprehensive estimation of the sums required for operating and maintaining the system in the base year.

Methodology : Costs will be estimated according to the method defined in Task 6.1. First, unit costs will be defined for Canadian labor and productivity rates and conditions in similiar operations. Second, the number of work hours required for each function identified in Task 5.2 R will be established. Finally, the product of labor rates and labor hours will yield labor-related operating costs. Other operating costs will be treated similarly.

Responsibility : TDC Contractor
Comments by TransRapid

Result : A complete list of unit and total costs for all aspects of system operation, as per Task 5.2 R. This will include but is not restricted to:

- drivers, operators
- other on-board personnel
- central control personnel
- vehicle and equipment maintenance personnel up to first line management but including administration
- energy demand
- maintenance supplier
- other operating and maintenance costs

Task 6.3 M

ESTIMATION OF OPERATING COSTS (MAGLEV)

Objective : To obtain a comprehensive estimation of the sums required for operating and maintaining the system in the base year.

Methodology : Costs will be estimated according to the method defined in Task 6.1. First, unit costs will be defined for Canadian labor and productivity rates and conditions in similiar operations. Second, the number of work hours required for each function identified in Task 5.2 R will be establishe.. Finally, the product of labor rates and labor hours will yield labor-related operating costs. Other operating costs will be treated similarly.

Responsibility : TransRapid
Coordination by Contractor.

Result : A complete list of unit and total costs for all aspects of system operation, as per Task 5.2 M. This will include but is not restricted to:

- drivers, operators
- other on-board personnel
- central control personnel
- vehicle and equipment maintenance personnel up to first line management but including administration
- energy demand
- maintenance supplier
- other operating and maintenance costs

Task 6.4

OPTIMIZE SERVICE AND SYSTEM

Objective : To make the necessary modifications to system definition, to ensure that each system fully exploits the inherent advantages of its technology.

Methodology : The first estimation of construction and operating costs will reveal major cost differentials between the two technologies. Upon analyzing these results, it may be found that a system is not optimally designed to exploit the corresponding technology's merits. The necessary revisions to that system's definition will be effected.

Responsibility : Contractor for Rail.
TransRapid for Maglev.

Result : A revised system definition for each technology.

Task 6.5

REVISE COST ESTIMATIONS

Objective : To update system construction and operating costs following the revised system definition(s) resulting from Task 6.4.

Methodology : As per Tasks 6.1 and 6.2.

Responsibility : Contractor for Rail.
TransRapid for Maglev.

Result : Revised system construction and operating costs.

Task 6.6

FINANCIAL ANALYSIS

Objective : To compare the costs and expected revenues of the two systems.

Methodology : Based on the revised cost estimates from Task 6.5 and, the expected ridership from Task 3.1 a full recovery unit ticket cost will be calculated that guarantees a satisfactory financial rate of return. This will be done using the MRAIL model. It will then be checked whether that fare is acceptable to the expected ridership and the necessary revisions and cycling will be effected.

Responsibility: CIGGT
Coordination by Contractor
Comments by TransRapid

Result : The ticket costs, expected revenues and financial rate of return for each system.

Task 7.1

EVALUATE TECHNICAL IMPONDERABLES

Objective : To identify, for each technology, the system elements susceptible to development or other technical risks and to evaluate their impact on cost and performance.

Methodology : This will be a qualitative evaluation.

Responsibility : Contractor for Rail.
TransRapid for Maglev.

Result : A qualitative evaluation of the technical risks associated with the development of each technology.

Task 7.2

ANALYZE WINTER OPERATION PROBLEMS

Objective : To identify and analyze possible operation problems with the maglev technology that differ from problems normally encountered with rail systems.

Methodology : Review of published reports on winter operation problems of GGT systems. Analysis of the maglev technical characteristics susceptible to operating problems in winter.

Responsibility : Contractor for locating background information and documentation and suggesting possible problem areas.
TransRapid for discussing the occurence of problems and suggesting solutions.

Result : A list of possible winter operation problems with an evaluation of their severity and a list of possible solutions, such as methods for protecting switches. An evaluation of reports and test results.

Task 7.3

IDENTIFY TECHNOLOGY SPIN-OFFS

Objective : To identify possible spin offs from the introduction of HSGT technology (whether rail or maglev) to the Canadian context.

Methodology : Find other applications for new technical principles, techniques and equipment used by HSGT systems.

This will be a qualitative evaluation, focusing on differences between the two technologies.

Responsibility : Contractor for rail;
TransRapid for Maglev.

Result : Discussion of other applications of HSGT technology.

Task 7.4

EVALUATE MANUFACTURING IMPACTS

Objectives : 1. To identify Canadian sources for equipment for the two HSGT systems.

2. To evaluate the approximate Canadian content of each system.

Methodology : Based on the lists of system elements prepared in Task 5.1, identify those

- that can be readily manufactured
- that could be manufactured under licence
- that are patent-protected
- that must be supplied by a foreign source

This identification will focus on the differences between the two systems.

Responsibility : TDC Contractor.
Comments by TransRapid.

Result : An approximate evaluation of the Canadian content for each system by major system elements.

Task 7.5

EVALUATE ENERGY IMPACTS

Objective : To identify and evaluate the major differences between the two systems as to their quantitative qualitative use of energy for operation and construction.

Methodology : Based on published data, and the estimated operating cost, evaluate the major energy requirements of each system. Outline the key differences and discuss. Focus will be on direct energy. Indirect energy will be considered only in cases where major differences are suspected.

Responsibility : TDC Contractor
TransRapid will comment.

Result : A list and evaluation of major differences in energy use between the two technologies.

Task 7.6

SOCIO-ECONOMIC IMPACTS

Objectives : 1. To identify the nature of socio-economic impacts of a HSGT system.

2. To outline the differences in impacts between the two technologies.

Methodology : Prepare a list of qualitative arguments.

Responsibility : TDC Contractor
Comments by TransRapid.

Result : A commented list of differences in socio-economic impacts.

Task 7.7

ENVIRONMENTAL IMPACTS

Objectives : 1. To identify the nature of environmental (visual, noise, etc.) impacts resulting from the complementation of a HSGT system.

2. To outline the differences in environmental impacts between the two technologies.

Methodology : This is a qualitative evaluation.

Responsibility : TDC Contractor
Comments by TransRapid.

Result : A commented list of differences in environmental impacts.

Task 7.8

EVALUATE TRAFFIC IMPACTS

Objective : To evaluate the differences in attractiveness for potential riders between the two technologies and the corresponding differences in ridership and revenues if any.

Methodology : To be defined.

Responsibility : TDC Contractor
Comments by TransRapid.

Result : The financial implications of the increase in ridership accruing to the more attractive technology.

Task 8.1

SUMMARY TECHNICAL COMPARISON

Objective : To identify the technical advantages and disadvantages of each technology and to compare the two with each other so as to outline the most significant technical differences.

Methodology : This task will be conducted as an internal design review.

Responsibility : Contractor and TransRapid jointly.

Result : Two tables of advantages and disadvantages with supporting text as required.

Task 8.2

SUMMARY FINANCIAL COMPARISON

Objective : To identify and summarize the major differences between the two technologies as to construction costs, operating costs, full-recovery unit ticket costs, and/or revenue.

Methodology : This task will be conducted as an internal design review.

Responsibility : Contractor and TransRapid jointly.

Result : A comparative table of the cost and revenue differentials with supporting text as required.

Task 8.3

SUMMARY IMPACT COMPARISON

Objective : To identify and summarize the major differences between the two technologies as to their impacts of various types.

Methodology : This task will be conducted as an internal design review.

Responsibility : Contractor and TransRapid jointly.

Result : A comparative table outlining the major impacts differentials, with supporting text as required.

Task 8.4

SENSITIVITY ANALYSIS

Objectives : 1. To identify key system and context parameters susceptible of significant variations.

2. To evaluate modifications of the comparison resulting from variations in these parameters.

Methodology : This task will be conducted as an internal design review. To evaluate the financial implications the procedure will be the same as in Task 6.6

Responsibility : Contractor and TransRapid jointly.

Result : A text describing the implications of variations in key parameters on the Result of Tasks 8.1 through 8.3.

Task 9.1

DRAFT FINAL REPORT

Objective : To prepare the draft of the report outlining the major results of the comparison.

Methodology : The final report as such will be relatively short. All technical and financial back-up material will be presented in appendices. Several portions of the report will have been already submitted to TDC during the course of the study.

Responsibility : TDC Contractor.
Comments by TransRapid.

Result : A draft report according to TDC report specifications

Task 9.2

COMMENTS BY TDC

Objective : TDC's own objectives.

Methodology : Not applicable.

Responsibility : TDC

Result : A commented version of the draft final reports.

CAN
DT 284
S2
S71

Task 9.3

FINAL REPORT

Objective : To make the necessary changes to the draft final reports to reflect TDC's comments.

Methodology : Not applicable.

Responsibility : TDC Contractor
TransRapid for its work.
CIGGT for its work.

Result : The end product of this study.